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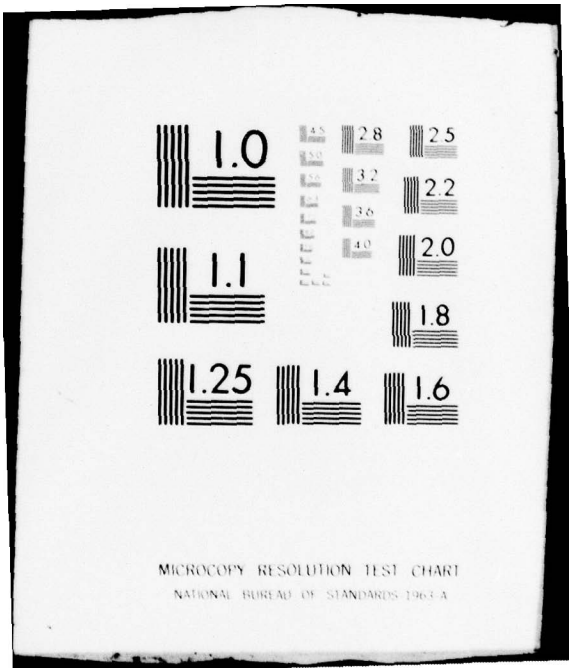
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TECHNICAL REPORT D-77-38

HABITAT DEVELOPMENT FIELD INVESTIGATIONS, MILLER SANDS MARSH AND UPLAND HABITAT DEVELOPMENT SITE, COLUMBIA RIVER, OREGON

APPENDIX D: PROPAGATION OF VASCULAR PLANTS ON DREDGED MATERIAL

by

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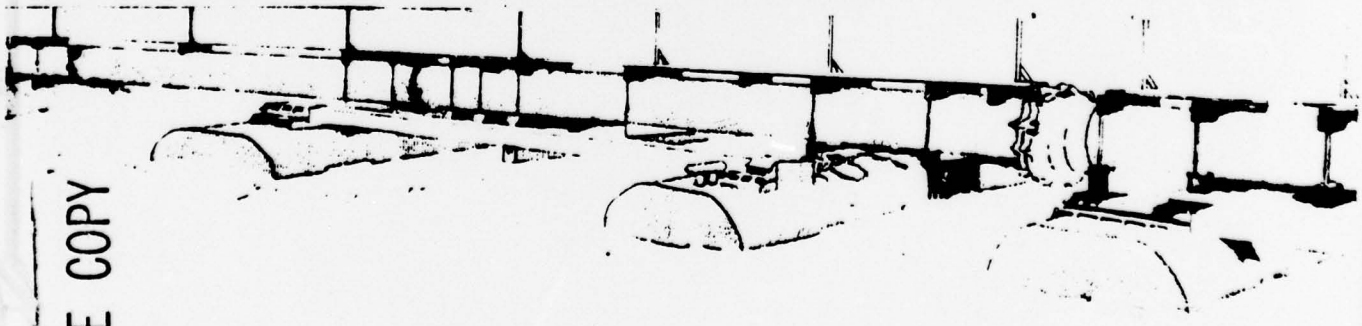
December 1978

Final Report



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HABITAT DEVELOPMENT FIELD INVESTIGATIONS, MILLER SANDS MARSH AND UPLAND HABITAT DEVELOPMENT SITE, COLUMBIA RIVER, OREGON

Appendix A: Inventory and Assessment of Predisposal Physical and Chemical Conditions

Appendix B: Inventory and Assessment of Predisposal and Postdisposal Aquatic Habitats

Appendix C: Inventory and Assessment of Prepropagation Terrestrial Resources on Dredged Material

Appendix D: Propagation of Vascular Plants on Dredged Material

Appendix E: Postpropagation Assessment of Botanical and Soil Resources on Dredged Material

Appendix F: Postpropagation Assessment of Wildlife Resources on Dredged Material

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Miller Sands, an island complex in the lower Columbia River, is largely derived from dredged material. Three distinct habitat types are recognized: a large vegetated upland island formed prior to 1940; an elongate barren sand spit formed primarily since 1970; and a cove protected by the island and the spit.

In July of 1975, a pilot study was conducted under contract with the Waterways Experiment Station (WES), in which a total of ten plots were planted (Continued)

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20. ABSTRACT (Continued).

with transplants of five species of vascular plants endemic to the area. The primary purpose of this pilot study was to identify the best plant materials for use in larger scale experiments in 1976.

Five experimental sites were selected in 1976 by WES to study the propagation of selected plant species: upland plantings consisting of monotypic plots and meadows, sand spit plantings, and intertidal plantings consisting of monotypic plots and a species mixture.

The upland experimental sites were located on the older, vegetated island. The upland plantings consisted of various experimental treatments with a total of nine seeded grass and legume species.

European beachgrass transplants were planted and fertilized on the upland portion of the sand spit. These plantings were made in conjunction with installation of sand fences to prevent wind erosion and sand deposition on the intertidal plantings.

The intertidal experimental sites were located on the east end of the sand spit in a protected cove. A total of eight species were established and subjected to experimental treatments to test propagule type, response to fertilizer, and response to elevation within the intertidal zone.

As a result of efforts at the Miller Sands site, much information has been generated regarding the feasibility of planting various intertidal and upland species. Such information should be useful in future endeavors to establish marsh habitat, and should be valuable in reducing costs of similar propagation efforts.

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SUMMARY

Miller Sands, an island complex in the lower Columbia River, is largely derived from dredged material. Three distinct habitat types are recognized: a large vegetated upland island formed prior to 1940; an elongate barren sand spit formed primarily since 1970; and a cove protected by the island and the spit.

In July of 1975, a pilot study was conducted under contract with the Waterways Experiment Station (WES), in which a total of ten plots were planted with transplants of five species of vascular plants endemic to the area. The primary purpose of this pilot study was to identify the best plant materials for use in larger scale experiments in 1976.

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PREFACE

All propagation aspects at the Miller Sands Habitat Development Site were performed by the Wave Beach Grass Nursery, Florence, Oregon. The work was done under Contracts DACW39-75-M-4816 (Pilot Study) and DACW39-57-76-C-0184 (Experimental Study) with the U. S. Army Engineer District, Portland, in cooperation with the Environmental Laboratory (EL), Waterways Experiment Station (WES), Vicksburg, Mississippi. The propagation work was initiated in the fall of 1975 and continued through summer 1977.

The principal investigator for Wave Beach Grass Nursery was Wilbur E. Ternyik. Seed cleaning of marsh species was done by David C. Nelson of Brown Seed Company, Vancouver, Washington. Seed testing and seed counts were done by Oregon State University, Seed Laboratory, Corvallis, Oregon.

The principal investigator wishes to extend his sincere thanks to the following individuals and their respective staffs who contributed in various ways to the success of this project: Ted Blahm, John Crawford, Kathy Fitzpatrick, Paul Heilman, Jean Hunt, La Rea Johnson, Don Leach, Ken Margolis, Paul Peloquin, Jack Rogers, Joyce Ternyik, and Bob Watson.

The scope of work was prepared by the following WES personnel: E. Paul Peloquin, A. Dale Magoun, Hollis H. Allen, and J. Scott Boyce. J. Scott Boyce and Ellis J. Clairain, Jr., were contract managers.

This report was prepared under the general supervision of John Harrison and Hanley K. Smith of EL. COL G. H. Hilt, CE, and COL J. L. Cannon, CE, were Commanders and Directors of WES during the period of study. Mr. F. R. Brown was Technical Director.

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APPENDIX D: PROPAGATION OF VASCULAR PLANTS ON DREDGED MATERIAL

PART I: INTRODUCTION

1. This report presents results of a study conducted by the Wave Beach Grass Nursery, Florence, Oregon, under contract with the U. S. Army Corps of Engineers. This study was part of the Habitat Development Project, a program of research to evaluate the feasibility of developing marshland and upland habitat on dredged material. Habitat development was one aspect of the Corps' Dredged Material Research Program (DMRP), which was designed to determine environmental aspects of dredged material disposal and to develop improved methods for the disposal and managed use of dredged material. The DMRP was under the direction of the Environmental Laboratory of the Waterways Experiment Station (WES) in Vicksburg, Mississippi.

2. Field evaluations of habitat development on dredged material were conducted at eleven locations throughout the United States. One study site selected in the Pacific Northwest was known as Miller Sands, a dredged material disposal site in the lower Columbia River. In addition to the activities reported here, other studies were conducted addressing wildlife populations, aquatic fauna, nutria control, and monitoring of plant growth.

Objectives

3. The objectives of this study were to establish vegetation in upland and intertidal areas within the Miller Sands study area, and to document the planting and cultural practices used.

Significance of Research

4. The study described herein examined the possibility of establishing habitat on dredged material for the purpose of maintaining or enhancing wildlife and fisheries habitat. These data provide a basis upon which future management decisions can be made with regard to habitat establishment on similar disposal areas, and assist with plant species selection and propagation techniques.

Pilot Study

5. A pilot study involving transplanting several marsh species was conducted on the sand spit area of Miller Sands in 1975 (Ternyik, 1977)*. Species tested in this work were common spikerush (Eleocharis palustris), Baltic rush (Juncus balticus), common rush (Juncus effusus), American bullrush (Scirpus validus), Lyngby's sedge (Carex lyngbyei), and tufted hairgrass (Deschampsia caespitosa). The plants were transplanted to fertilized and unfertilized plots. Where used, fertilizer was applied at a rate of 100 kg per hectare of 11-55-0 (N-P-K), three to four weeks after planting. Best results were obtained with tufted hairgrass, Lyngby's sedge and common rush.

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* Ternyik, Wilbur E. 1977. Pilot Propagation of Vascular Plants on the Miller Sands Habitat and Marsh Development Site, Columbia River, Oregon. Internal Working Document D-77-2. Environmental Laboratory, Waterways Experiment Station, Vicksburg, Miss.

PART II: DESCRIPTION OF THE STUDY AREA

6. Miller Sands is a horseshoe-shaped island located between River Miles 22 and 25 in the Columbia River, Clatsop County, Oregon (Figures 1 and 2). The island is one of many located within the boundary of the Lewis and Clark National Wildlife Refuge.

History

7. Miller Sands was constructed in 1932 from sediments dredged from the Columbia River navigation channel. The repeated dredging of the channel and the recurring deposition of dredged material on the site have led to the development of an island-marsh complex of about 95 ha.

Climate

8. The climate of the lower Columbia River is Pacific Northwest Maritime, being characterized by wet winters and dry summers. Maximum summer temperatures for this region range between 21° and 27°C. Maximum winter temperatures range between 7° and 13°C. Average precipitation reported for Astoria, Oregon (19.3 km west of the site), is 127.5 cm per year. About one to two percent of the total precipitation is reported annually as snowfall.

Hydrology

9. Peak flows of the Columbia River occur in the months of April, May and June as a result of spring runoff from melting snow. The stream gradient of the lower Columbia River from Bonneville Dam to the Pacific Ocean is very gentle. The floodplain varies between 3.2 and 9.7 km in width. Intruding tidal ocean water tends to move upstream under the less dense river water and may extend as far as River Mile 23 (Miller Sands) near Harrington Point. As the ocean water advances, it causes a

river-flow reversal, surface and bottom, that has been observed as far upstream as River Mile 53. The tidal range during low river flow varies from 2.1 to 2.4 m at Astoria.

Soils

10. Miller Sands is composed of a dredged material classified as clean, fine sand with 10 percent finer than 0.1 millimeter in diameter. The dredged material deposited at Miller Sands is separable into two age classes by location: the older island (constructed in the early 1930's), and the more recently deposited sand spit (1974-1976). Organic debris consisting of wood chips and logs may underlie various portions of both the island and the spit.

Vegetation

11. The Miller Sands island-marsh complex is composed of four or more easily recognized plant communities. The marshland portions of the site support plants such as Lyngby's sedge, spike rush, and tufted hair-grass. The higher intertidal elevations are dominated by reed canarygrass (Phalaris arundinacea) and willow (Salix spp.). Portions of the island contain cottonwood (Populus spp.)and alder (Alnus sp.) stands with isolated trees occurring in the open meadows. The majority of the island interior is best described as a horsetail-grass-moss community. Most of the recently placed sand spit is unvegetated. One threatened species, the Columbia River willow (Salix fluviatilis) is known to occur on the island.

PART III: METHODS AND MATERIALS

12. Five separate types of plantings were selected for this study: upland plantings consisting of monotypic plots and meadows, sand spit plantings, and intertidal plantings consisting of monotypic plots and a species mixture (Figure 3).

Upland Plantings

13. An 18 ha upland planting was established on the main island in the Autumn of 1976. The purpose of the planting was to improve the area from a wildlife standpoint, and test various propagation techniques.

Plant species

14. Nine plant species were selected for testing: tall wheatgrass (Agropyron elongatum), white clover (Trifolium repens), barley (Hordeum vulgare), Oregon bentgrass (Agrostis oregonensis), red clover (Trifolium pratense), reed canarygrass (Phalaris arundinacea), red fescue (Festuca rubra), tall fescue (Festuca elatior), and hairy vetch (Vicia villosa).

Propagule collection and storage

15. Seeds were purchased from Adams Feed and Seed Company, Springfield, Oregon, and were stored in burlap, paper, or woven linen containers, as appropriate. The seeds were stored in an aluminum warehouse in Florence prior to transfer to the site, at which time they were stored in a waterproof tent with a plywood floor.

Experimental design

16. The upland area measured 242 m x 744 m and was divided into three meadows of equal size (242 m x 248 m). A 70 m x 117 m subunit was established within each unit. Each of the three meadows, excluding the subunits, was seeded with a mixture of one legume and two grass species (for a total of nine species). Each of the subunits was divided into 36 monotypic plots. The monotypic plots were subjected to treatment by individual species (three species plus one control) and fertilizer rate (two levels of fertilizer plus no fertilizer) with three replicates. Each subunit tested the three species represented in its respective meadow.

Site preparation

17. A John Deere 350 diesel bulldozer was used to clear trees and even the surface. Clearing for the site required five full days of labor (dozer operator plus one laborer).

18. One large stand of Scot's broom (Cytisus scoparius) in the southeast corner of the site was left uncleared because the area had been identified as prime bird nesting habitat. Woody plants removed were identified as Scot's broom, black cottonwood (Populus tricocarpa), both natural invaders on the island, and olive (Eleagnus sp.) which was planted as a result of the Oregon State Game Commission's previous attempts to establish improved habitat. All large Sitka spruce (Picea sitchensis) were left at the request of the the U. S. Fish and Wildlife Service.

19. After clearing and levelling the site, the bulldozer was used to disc the site with a 3-m tandem disc attached to a hydraulic three point hitch. Stands of common horsetail (Equisetum arvense) and seashore lupine (Lupinus littoralis) were dense enough in some areas to damage the disc or render it ineffective. The tractor and plow worked well, but proved to be too time consuming, and finally a disc harrow (Ford 223) was employed. This disc turned the material with ease. Due to its weight, the disc was pulled with the bulldozer.

20. After the surface had been disced, a levelling float was constructed of 10-cm x 30-cm and 5-cm x 30-cm planks to float level the field. The field was dragged until an acceptable seedbed was prepared (Figure 5), and then the entire field was rolled with a cultipacker pulled by a tractor.

Fertilization

21. An 11.7-11.7-11.7 (N-P-K) fertilizer with zinc additive was used for all fertilization. The upland meadows, excluding the subunits, were fertilized twice, once in September 1976 and again in May 1977. The initial rate was 224 kg/ha,* and the final rate was 448 kg/ha. Each of the monotypic plots in the subunits was fertilized twice (October 1976 and April 1977) at one of the following rates: 0 kg/ha, 224 kg/ha, and 448 kg/ha. The upland units were fertilized with a tractor-mounted cyclone seeder, the monotypic plots were fertilized with a hand held cyclone seeder (Figure 6).

* Although 11.7-11.7-11.7 fertilizer was used, application rates of N-P-K were calculated and are provided based on 10-10-10 fertilizer.

Seeding

22. All seeding occurred in October 1976 following the initial fertilization. The upland meadows, excluding the subunits, were seeded with a tractor-mounted cyclone seeder. Each meadow was seeded with a mixture of two grass and one legume species. In all treatments, the legumes were innoculated the day of seeding using the commercial inoculatant Nitragin at the recommended rate of 190 g per 25 kg. Even dispersal of Oregon bentgrass seed was not possible because of their minute size. The seeds were rolled-in using a tractor drawn cultipacker. The monotypic plots in the subunits were seeded (one species per monotypic plot) with a hand held cyclone seeder, raked into a depth of 0.6 cm and compacted with a tractor drawn cultipacker. The seeding rates in the meadows and subunits were similar and are given in Table 1. Following seeding, the use of the area by birds was significant, resulting in a loss of an undetermined number of seeds.

Sand Spit Plantings

23. European beachgrass (Ammophila arenaria) was planted on the upland portion of the sand spit directly east of the intertidal plantings (Figure 3). The purpose of these plantings was to reduce wind erosion of the sand spit, and the subsequent deposition of the eroded material on the intertidal plantings. European beachgrass was selected because of its proven value for sand stabilization along the Pacific Coast.

Site preparation

24. The site was prepared for planting by leveling with a bulldozer. Two 1.2 m tall redwood lathe snowfences were installed on a north-south orientation to further reduce erosion. The fences were parallel and 9 m apart.

Planting

25. Two year old planting stock was obtained from a nursery in Florence, Oregon, and planted in January and May 1977. All plantings were fertilized with nitrogen fertilizer applied in the form of ammonium sulfate (21-0-0). The first plantings were fertilized at a rate of

224 kg/ha in January and again in April 1977. The May plantings were fertilized in the same month at a rate of 448 kg/ha. Transplants were spaced at 0.5 m intervals. The plantings extended 250 m in a north-south orientation, and varied between 30 and 45 m in an east-west orientation.

Intertidal Plantings

26. The intertidal plantings consisted of a block of single species plots (monotypic) flanked on two sides by a mixture of marsh species (Figure 3). Eight species of plants were tested in the intertidal plantings: tufted hairgrass (Deschampsia cespitosa), slough sedge (Carex obnupta), Lyngby's sedge (Carex lyngbyei), arrowhead (Saggitaria latifolia), American bullrush (Scirpus validus), common rush (Juncus effusus), yellow flag (Iris pseudacorus), and water plantain (Alisma plantago-aquatica). These species were selected on the basis of success in an earlier pilot study, and/or because they were believed to be of value in the lower Columbia estuary.

Site preparation

27. Unvegetated sandy dredged material was graded to an elevation from about mean lower low water (MLLW) to 2.3 m above MLLW. The grading was generally successful except that the lower perimeter of the intertidal area was eroded and uneven.

Experimental design

28. The intertidal plantings, as shown in Figure 7, were established in a series of planted study plots. Two basic types of plots were employed: a block of 270 monotypic (single species) plots measuring 214 m x 214 m, and two mixed species plots each 214 m x 10 m, bordering the monotpyic plots. Each monotypic plot measured 11.9 m x 14.2 m and was bordered by a 1.0 m unplanted buffer. Within the monotypic plots an array of 30 experimental treatments were conducted. The monotpyic experimental treatments included two plant species and an unplanted or control species, two types of propagules, five fertilizer rates, and three elevational tiers. Each treatment was replicated three times. Only tufted hairgrass and slough sedge were planted in the monotypic plots.

29. The mixed species plots were located in elongate rectangles along the elevational gradient bordering the north and south sides of the monotypic plots. Eight species, listed above, were tested in the mixed species plots.

Planting

30. All species were sprigged and seeded in July and August 1976. Because of poor results from the first seeding, a second seeding of tufted hairgrass and slough sedge in the monotypic plots was conducted May 1977. Sprigs in the monotpyic plots were planted on 0.5 m spacings with 594 sprigs per plot (Figures 8 and 9). Seeds in the monotypic plots were broadcast by hand at a rate of 16,900 seeds per plot ($100/m^2$) during the first planting and 34,000 seeds per plot ($200/m^2$) during the second planting (Table 2). The mixed species plots were sprigged and seeded wtih 20 alternating rows of Lyngby's sedge, slough sedge, tufted hairgrass, American bullrush, and arrowhead (seeds only). All sprigged plants were placed on 0.5 m x 0.5 m spacings. Sprigs of yellow flag and water plantain were established in the upper elevation plots. The rows traversed the three intertidal elevational ranges (Figure 10).

Fertilization

31. All fertilization was conducted using 11.7-11.7-11.7 inorganic fertilizer spread at low tide with a hand held cyclone seeder. Fertilizer was applied to the monotypic plots in one of five treatments: 0 kg/ha; 1220 kg/ha at time of planting; 2440 kg/ha at time of planting; 610 kg/ha at time of planting and 610 kg/ha in April 1977; 1220 kg/ha at time of planting at 1220 kg/ha in April of 1977. The fertilizer applied to the monotypic plots was raked in during the first application but not raked in during the spring application (Figure 11).

32. Fertilizer was applied to the mixed species plantings at the time of planting at a rate of 2440 kg/ha. The mixed species area was subsequently fertilized at a rate of 610 kg/ha in May 1977. Neither application was raked in and a substantial, although unknown amount of fertilizer was washed away by the tide.

Species Propagation

Tufted hairgrass

33. Seeds. Seeds heads were collected in August from marshes in Oregon. The heads were dried at 21-24°C, and subsequently threshed. Seeds were separated by screening, and sound seed isolated with a pneumatic separator. Dried seeds were stored in plastic bags at 2°C. Tetrazolium testing indicated 90 percent viability.

34. The tufted hairgrass seeds in the monotypic plots were spread with a hand held cyclone seeder. The seeds were mixed with sand to improve their distribution. In the mixed species plots seeds were planted with a small push type row seeder. Mud buildup on the wheels of the seeder hindered even distribution. Because the seeds are minute they were difficult to handle, sow and hold in place.

35. Sprigs: Sprigs were collected in marshes near Miller Sands. Clumps were dug with a shovel and the roots clipped to facilitate separation of plants. Most plants were transplanted within eight hours, and were temporarily stored in baskets sunk within the intertidal area. Tile spades were used to produce a 30 cm deep hole, 5 cm wide at the surface. Plants were placed on the bottom of the hole and then raised until the root collar was even with the surface. The planter then closed the hole by applying full weight to one side.

Slough sedge

36. Seeds. Seeds were collected in August from a freshwater marsh in the Siuslaw River, Oregon. Seeds were gathered by stripping seed heads. They were subsequently dried, hand threshed and screened. Techniques for cleaning and storage of slough sedge seeds were similar to those previously described for tufted hairgrass. Tetrazolium testing indicated 66 percent viability.

37. Slough sedge seeds were broadcasted with a hand held cyclone seeder on the monotypic plots, and planted with a small push type row seeder in the mixed species plots.

38. Sprigs. Sprigs were collected in the Siuslaw River, and stored in ponds for approximately four days before being transported to the site.

Care was taken to avoid excessive heating or drying of the plants during travel. The plants were stored at the site in baskets sunk within the intertidal zone. In some cases, plants were stored for two weeks prior to planting; however, this did not appear to reduce transplant success. Slough sedge was sprigged in the same manner as tufted hairgrass.

Lyngby's sedge

39. Seeds. Although this is a common marsh species, reliable seed sources were difficult to locate. Collection also proved labor intensive. Seeds were cleaned and stored in a manner similar to the seeds of tufted hairgrass. Tetrazolium testing indicated 62 percent viability. Seeds were planted with a small push type row seeder.

40. Sprigs. Sprigs were collected from a marsh on Miller Sands and transplanted immediately. Sprigs were planted three culms per hill. The planting technique was similar to tufted hairgrass.

Arrowhead

41. Seeds. Arrowhead is an uncommon plant in Oregon and considerable difficulty was encountered in locating seed-bearing plants. Two collection sites, both near the Willamette River, were utilized. The seeds were cleaned and stored using techniques similar to those used for tufted hairgrass. Tetrazolium tests indicated 33 percent viability. Seeds were planted with a small push type planter. Difficulty was encountered because the fleshy seed head rapidly decomposes and may destroy the seeds. Additionally, the seeds mature at differential rates and thus required careful selection.

42. Sprigs. This is a rare plant in Oregon and consequently no sprigs were collected.

American bullrush

43. Seed. American bullrush is a common plant in Oregon, and collection sites were the Siuslaw River and Siltcoos Lake. Seed collection is difficult because of the height of the seed head and variable seed production. Tetrazolium tests indicated 75 percent viability. Seeds were cleaned and stored in a manner similar to that described for tufted hairgrass. Seed was planted using a small push type row seeder.

44. Sprigs. Sprigs were collected near Miller Sands and transplanted

the same day. The rhizomes were dug, washed clean and cut into sections. Each section of a transplanted rhizome contained at least one shoot. Sprigs were planted in a manner similar to tufted hairgrass.

Common rush

45. Seeds. Seeds were collected on the Siuslaw River. Because of their minute size, and difficulty in separating the seed from the fruit, it was not possible to handle the seeds in a normal manner. Seed capsules containing seeds were planted with a small push type row seeder.

46. Sprigs. Sprigs were collected on the Skipanon River. They were collected, handled and planted in a manner similar to that described for tufted hairgrass.

Water plantain and yellow flag

47. Sprigs. Plants of both species were collected near Miller Sands and transplanted immediately. Roots were not cleaned, and the material was planted with soil intact in holes dug with a hand trowel.

PART IV: PROPAGATION COSTS

Seed Collection

Upland plantings

48. Seeds for the upland plantings were purchased from Adams Feed & Seed Company, Springfield, Oregon. Actual cost for each species is presented in Table 3.

Intertidal plantings

49. Seeds for the intertidal monotypic plots were collected in advance of the contract by the contractor. Costs associated with seed collection are indicated in Table 4. These costs do not reflect search and collection time or equipment costs. The reader is cautioned that the costs presented in Table 4 represent limited field testing. Additional practical application may reduce the seed cost substantially. Notes on various species are presented below.

50. Slough sedge. Seeds of this species, because it grows in vast stands and at an even height at maturity, may be best collected mechanically. Such a technique would substantially reduce costs.

51. Tufted hairgrass. With adaptation, machine seed harvest would be possible, and that would reduce costs. Since completely ripe seed heads shatter during harvest, careful timing of collection is essential.

52. American bullrush. Because of this species' height and normally marshy habitat, collection of seed is difficult. Field observations by the author in the fall of 1977 at Young's River near Astoria, Oregon, revealed an average of 7 to 11 seeds per head.

53. Common rush. Little accurate information was obtained on this species due to the small size of its seeds (0.4 mm) and the difficulty encountered in removing the seed from the seed capsules.

Sprig Collection

Sand spit plantings

54. European beachgrass was purchased from a commercial nursery,

Wave Beachgrass Nursery, Florence, Oregon, at a cost of $14 per 1,000 culms. A total of 130,500 culms were used during the study at a total cost of $1,827.

Intertidal plantings

55. Cost varied with each species due mainly to available supply. The late season start made it difficult to select plants not requiring extensive topping. Table 5 presents the costs associated with collection of marsh sprigs.

Seed Storage

Upland plantings

56. Seeds were stored, following purchase, in an aluminum warehouse owned by the contractor. Following transfer to the Miller Sands site, seeds were stored in a waterproof Army squad tent which necessitated a frame, plywood floor and labor for construction. Approximate total cost of the tent was $474. Approximately half of this cost can be applied to the process of seed storage.

Intertidal plantings

57. All marsh seed storage and cleaning was done by Brown Seed Storage Company, Vancouver, Washington, under a separate contract with WES. Seeds were sealed in plastic bags and stored at $2^{\circ}C$.

Sprig Storage

Sand spit plantings

58. There was very little storage cost associated with the European beachgrass. It was heeled-in at the site, at a cost of approximately $50 for labor.

Marshland plantings

59. All sprigs were stored in plastic baskets placed in holes dug in the intertidal zone. Eight baskets were purchased at $5 each, for a total cost of $40.

Seed Planting Costs

Upland plantings

60. Site preparation, planting and fertilizing, logistics and down time costs relating to upland plantings are presented in Table 6. Site preparation costs totalled $3,699, and planting and fertilizing costs totalled $3,298. Logistic costs were $1,914 and costs associated with down time approximated $930. Total planting costs for the upland meadows, excluding initial equipment investment costs, were $9,841 or $546 per hectare.

Intertidal seeding

61. Due to almost total failure in establishing marsh plants by seeding in the intertidal plots and intertidal mixture, no cost figures were developed.

Sprig Planting Costs

Sand spit plantings

62. Cost figures related to European beachgrass plantings on the sandspit are shown in Table 7. The total cost was $3,749 or approximately $1,100 per hectare. It should be noted that considerable time was lost due to inclement weather conditions.

Intertidal planting

63. Labor requirements for planting transplants in the intertidal mixture and intertidal plots varied by species and experimental design. Man-hours required to dig transplants of each species are presented in Table 5. Personnel costs necessary to plant transplants are shown in Table 8. Pooled costs for collecting and planting of transplants are shown in Table 9. The costs associated with the sprigging of the intertidal area, exclusive of plantings cost were $1,478 or $328 per hectare.

Logistic Costs

64. Consideration of the site location is of extreme importance when projecting future costs relating to marsh establishment. In the case of the Miller Sands study, the location necessitated 9.7 km one-way of water travel over the roughest stretch of water in the lower Columbia River system. The Miller Sands site was bordered by shallow water, which posed considerable difficulty in getting close enough to the upland area to unload equipment and supplies. Such a situation necessitates special equipment.

65. The nature of the job required the transport of massive amounts of supplies. Compounding the problem was the fact that only one landing craft was available in the lower Columbia River region. Since the demand for use of the landing craft is constant, it was at times necessary to move equipment to the island on small barges towed by the contractor's 6.1 m boat. Such towing required 3-1/2 hours one-way under favorable conditions.

66. Distance to the site, adverse weather conditions, and the lack of navigational aids and landing sites contributed significantly to the cost of this study.

Cost Conclusions

67. Habitat development at Miller Sands was difficult from a logistic standpoint, and in many ways represents a worst case situation from the standpoint of cost. The true costs of habitat development at this site are difficult to determine because of the influence of research costs is not entirely separable. It can, however, be stated that the cost of propagation of a hectare of upland habitat at Miller Sands (seeded) would be less than $600 per hectare. The cost of propagation of marsh habitat at Miller Sands (tufted hairgrass and slough sedge sprigged at 1 m intervals) would be less than $1,100 per hectare.

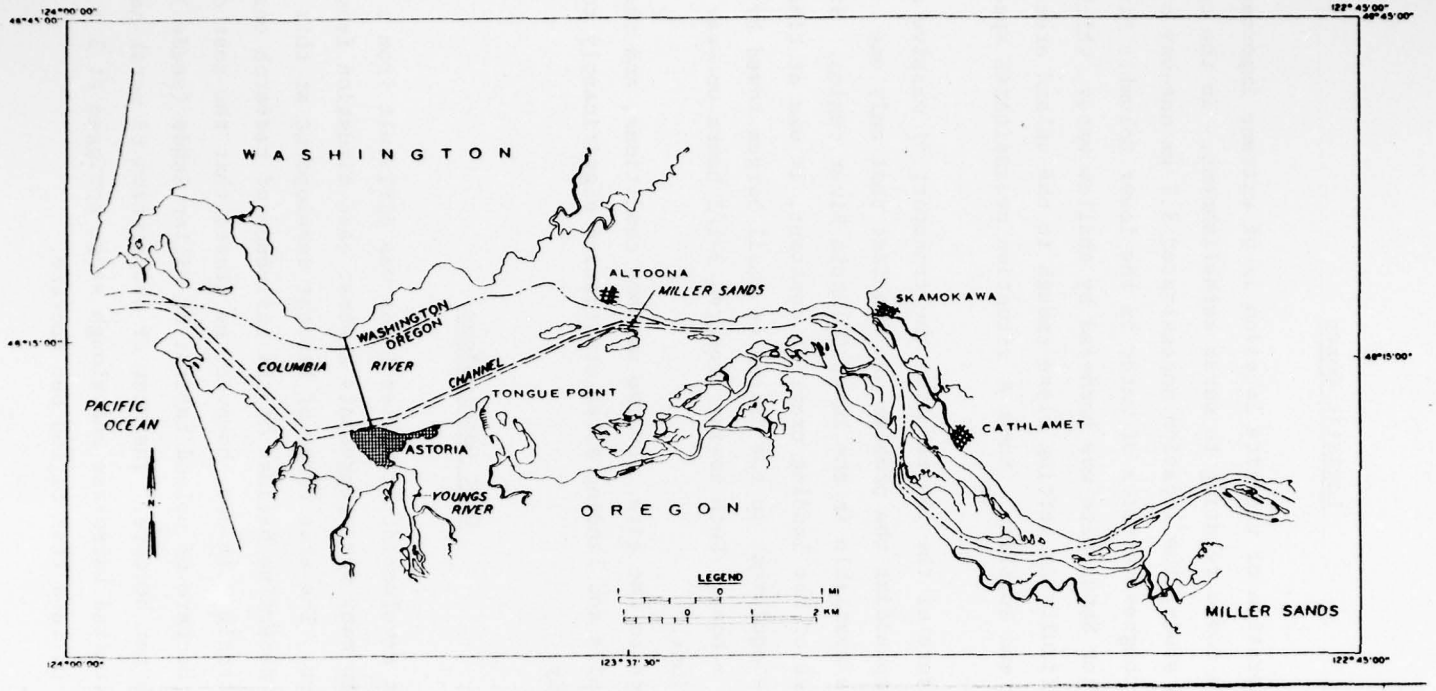

Figure 1. Geographical location of the Miller Sands Marsh and Upland Habitat Development Site, Columbia River, Oregon

Figure 2. Aerial view of Miller Sands, illustrating older vegetated dredged material and more recently disposed material

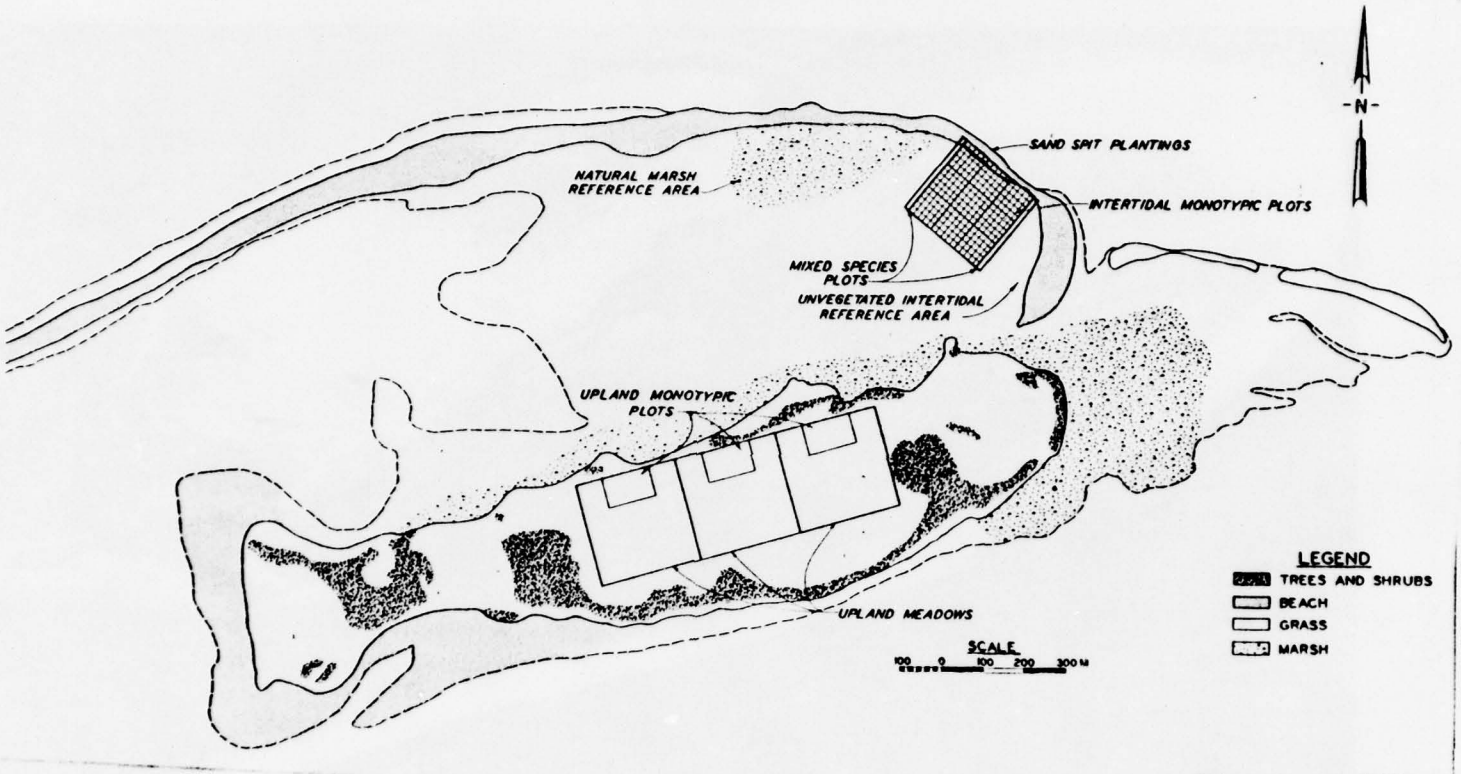

Figure 3. Field layout of the upland, sandspit, and intertidal areas at Miller Sands

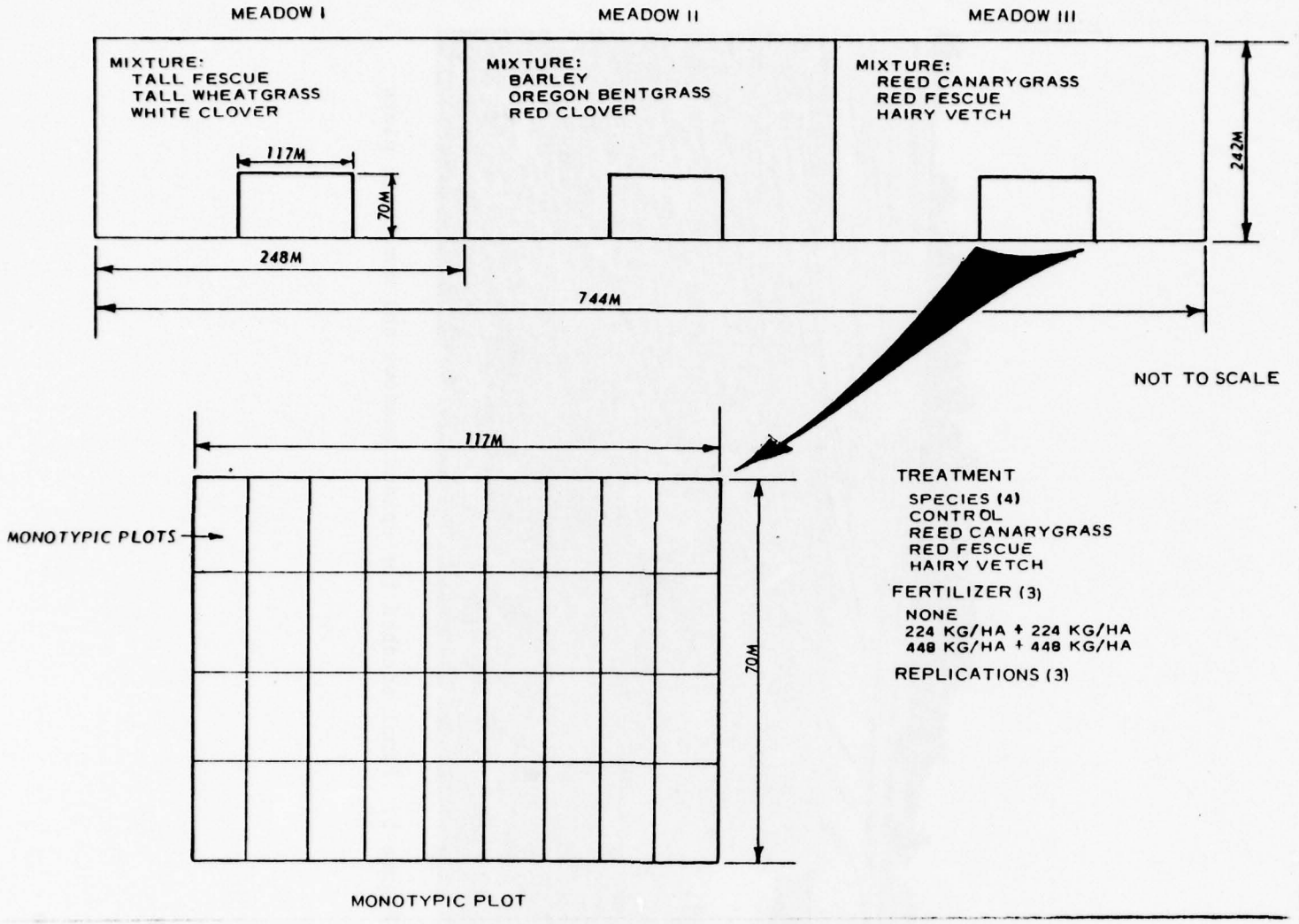

Figure 4. Design of the upland plantings showing three units and three subunits. Each subunit is partitioned into 36 monotypic plots

Figure 5. Final seedbed for upland meadows and monotypic plots

Figure 6. Application of fertilizer on the upland meadows using a rubber tired tractor and mounted spreader

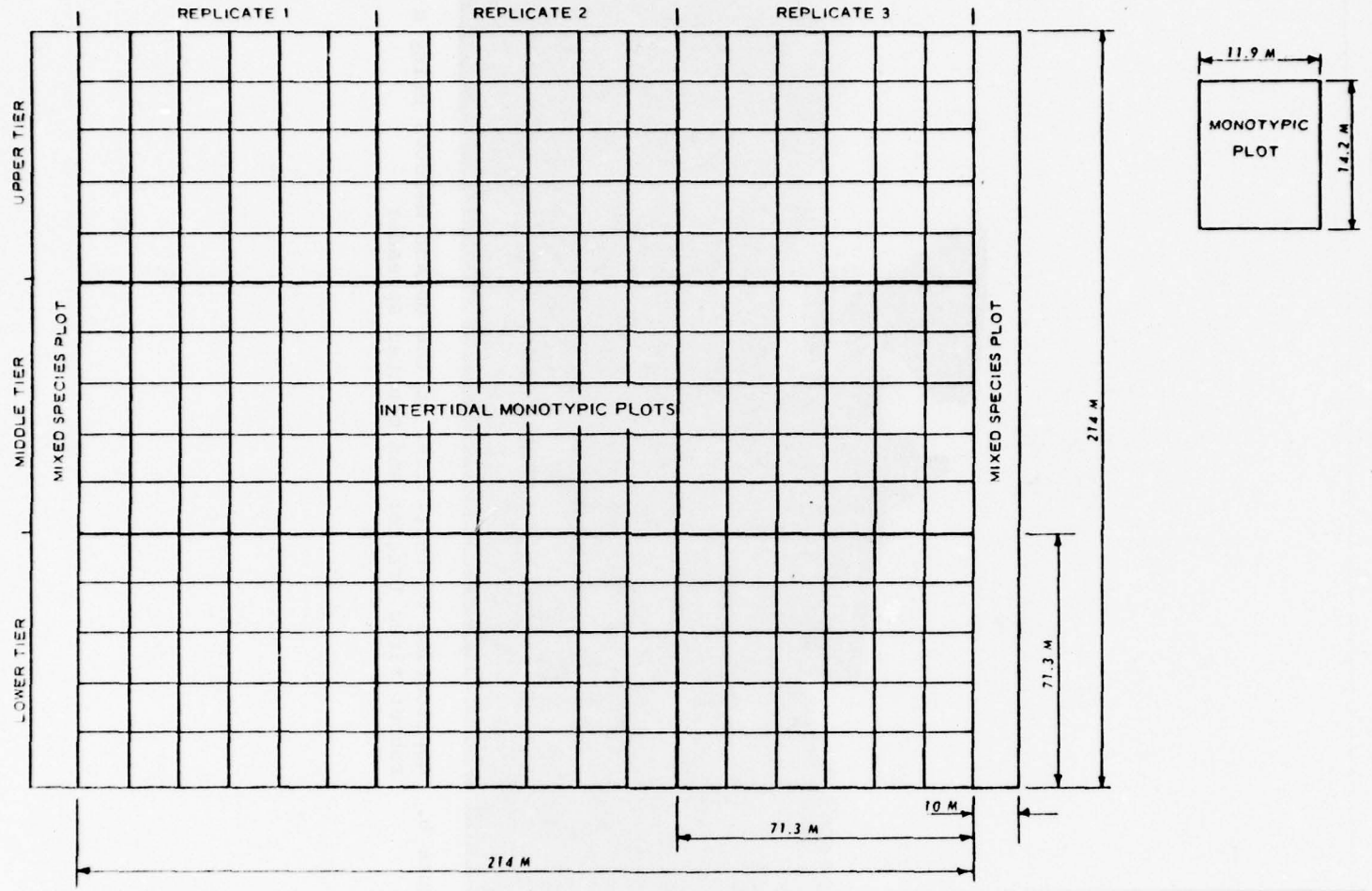

Figure 7. Field layout of intertidal plantings in the monotypic plots and intertidal mixture areas

Figure 8. A wooden rake with nails placed on 0.5 m centers was used to mark location for planting of intertidal monotypic plots

Figure 9. Planting of transplants in intertidal monotypic plots

Figure 10. Two rows of transplants enclosed each row of seed at the intertidal mixture plot

Figure 11. Raking fertilizer into a tufted hairgrass intertidal monotypic plot

Table 1

Plants and Seeding Rates Used in Upland Plantings

Species	Seeding Rate (kg/ha)	Seed/g	Seed/m^2	Viability (%)
Tall fescue	6.3	480	302	95
Tall wheatgrass	19.2	156	299	90
White clover	1.8	1,640	295	95
Barley	106.0	28	297	95
Bentgrass	0.24	11,400	274	90
Red clover	5.3	570	302	92
Reed canarygrass	0.30	1,000	30*	90
Red fescue	0.26	1,100	29*	95
Hairy vetch	71.0	43	305**	90

* Low seeding rate applied by error

** Hairy vetch was seeded at 150 seed/m^2 on the meadows, 305 seed/m^2 on the monotypic plots

Table 2

Seeding Rates for Intertidal Monotypic Plots

Species	Seeding Rate (kg/ha)	Seed/g	Seed/m^2	Viability (%)
Tufted hairgrass	0.41*/0.82**	2450	100*/200**	90
Slough sedge	2.02***/4.04**	495	100***/200**	66

* Planted 8/24/76
** Planted 5/13/77
*** Planted 7/29/76

Table 3

Seed Purchase Costs for Upland Plantings

Species	Cost/kg	Seeding Rate (kg/ha)	Cost/ha
Tall fescue	$0.70	6.3	$ 4.41
Tall wheatgrass	1.71	19.2	32.83
White clover	2.42	1.8	4.35
Barley	0.22	106.0	23.32
Bentgrass	2.09	0.2	0.42
Red clover	2.86	5.3	15.16
Reed canarygrass	2.16	0.3	0.65
Creeping red fescue	1.54	0.26	0.40
Hairy vetch	0.86	71.0	61.06

Table 4

Seed Propagule Collection Costs for Intertidal Plantings

Species	Seeds collected per man hour	Seeds/kg	kg/hr	Cost/kg*
Slough sedge	280,100	719,900	0.39	$15.42
Tufted hairgrass	1,389,300	2,450,300	0.57	10.56
Lyngby's sedge	75,400	630,000	0.12	50.16
American bullrush	31,300	692,000	0.04	113.56
Arrowhead	435,900	3,527,400	0.12	48.54
Common rush	Not Available			

* Cost estimated at $6/man hour excludes equipment cost and travel time.

Table 5

Man Hour and Labor Costs for Digging Marsh Transplants

Species	Plants dug per man hour	Cost per* 2,500 plants**	Cost per 10,000 plants***	Cost per 40,000 plants****
Tufted hairgrass	1000	$20	$80	$320
Slough sedge	350	57	228	913
Lyngby's sedge	350	57	228	913
Common rush	250	80	320	1280
American bullrush	100	200	800	3200

* Cost computed at $8/man hour, excludes equipment cost and travel time.
** Sufficient to plant 1 ha at 2 m spacing.
*** Sufficient to plant 1 ha at 1 m spacing
**** Sufficient to plant 1 ha at 0.5 m spacing.

Table 6

Costs Associated with Upland Plantings

Item		Cost
Site Preparation		
Dozer and Operator (120 hours @ $ 24.50)	$2,940	
Tractor and Plow (31.5 hours @ $16.50)	519	
Labor (40 hours @ $6.00)	240	
Total		$3,699
Planting and Fertilizing		
Seed, fertilizer	2,514	
Tractor and Spreader with Operator (32 hours @ $ 18.50)	592	
Labor (32 hours @ $ 6.00)	192	
Total		3,298
Logistics		
Tug and Barge	714	
Landing Craft	600	
Boat	400	
Sled	200	
Total		1,914
Down Time		
Tractor Rental	200	
Labor (80 hrs @ $6.00)	480	
Boat Standby (5 days @ $50.00)	250	
Total		930
	TOTAL COST	$9,841

Table 7

Costs Associated with Sand Spit Plantings

Item	Cost	
EQUIPMENT COSTS		
Small tools (tile spades, buckets, spreaders, etc.)	$ 50	
Total		$ 50
SITE PREPARATION--performed by Corps Portland District		
PLANTING & FERTILIZING		
Plants	1,827	
Labor 10 man days @ $64/day	640	
Fertilizer 900 lbs of 21-0-0 @ $118/ton	53	
Total		2520
LOGISTICS (cost transporting transplants to Island)		
Pickup (744 miles @ .15/mile)	111	
Driver (2 days @ $64/day)	128	
20' Boat (3 days @ $150/day)	450	
16' Aluminum Sled (5 days @ $20/day)	100	
Total		789
DOWN TIME		
Labor (6 man days @ $64/day)	384	
Total		384
TOTAL COST		$3,743

Table 8

Man Hours and Labor Costs for Hand Planting Marsh Transplants

Species	Plants planted per man hour	Cost per* 2,500 plants**	Cost per 10,000 plants***	Cost per 40,000 plants****
Tufted hairgrass	130	$154	$616	$2454
Slough sedge	148	135	540	2162
Lyngby's sedge	148	135	540	2162
Common rush	148	135	540	2162
American bullrush	120	167	667	2667

* Cost computed at $8/man hour, excludes equipment costs and travel time
** Sufficient to plant 1 ha at 2m spacing.
*** Sufficient to plant 1 ha at 1m spacing.
**** Sufficient to plant 1 ha at 0.5m spacing.

Table 9

Man Hours and Labor Costs for Digging and Planting Marsh Transplants

Species	Plants dug and planted per man hour	Cost per 1 plant*	Cost per 2,500 plants**	Cost per 10,000 plants***	Cost per 40,000 plants****
Tufted hairgrass	115	$0.07	$174	$696	$2783
Slough sedge	104	0.08	192	769	3077
Lyngby's sedge	104	0.08	192	769	3077
Common rush	104	0.08	192	769	3077
American bullrush	54	0.15	370	1481	5926

* Computed at $8.00 per hour, excluding equipment cost and travel time.
** Sufficient to plant 1 ha at 2m spacing.
*** Sufficient to plant 1 ha at 1m spacing.
**** Sufficient to plant 1 ha at 0.5m spacing.

Table 10

Costs Associated with Intertidal Plantings*

Item	Cost	
Equipment Cost		
Small tools, shovels, buckets, pruners, spreaders, etc.	$350	
Total		$350
Site Preparation - performed by Corps Portland District		
Fertilizing		
Fertilizer and labor for Monotypic Plots	254	
Fertilizer and labor for Intertidal mixture	**	
Total		254
Logistics (cost for transporting seed to Island)		
Monotypic plots	475	
Intertidal Mixture	12	
Total		487
Down Time		
Labor	387	
Total		387
TOTAL COST		$1478

* Cost projected does not include labor expended in planting.

** Data loss

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Ternyik, Wilbur E
Habitat development field investigations, Miller Sands marsh and upland habitat development site, Columbia River, Oregon; Appendix D: Propagation of vascular plants on dredged material / by Wilbur E. Ternyik, Wave Beach Grass Nursery, Florence, Oregon. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1978.
42 p. : ill. ; 27 cm. (Technical report - U. S. Army Engineer Waterways Experiment Station ; D-77-38, Appendix D)
Prepared for Office, Chief of Engineers, U. S. Army, Washington, D. C., under Contract No. DACW39-57-76-C-0184 (DMRP Work Unit No. 4B05G)
1. Columbia River. 2. Dredged material. 3. Field investigations. 4. Habitat development. 5. Habitats. 6. Marsh development. 7. Miller Sands Island. 8. Plants (Botany). 9. Vascular plants. 10. Vegetation establishment. 11. Waste disposal sites. I. United States. Army. Corps of Engineers. II. Wave Beach Grass Nursery. III. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Technical report ; D-77-38, Appendix D. TA7.W34 no.D-77-38 Appendix D

$0.00